

Health and Environmental Studies Using Ion Beam Techniques

Introduction

The PIXE Health and Environmental activities at the Ion Beam Laboratory group of ITN, are directed to the elemental characterisation of materials.

A special emphasis has been given to the Biomedical and Environmental areas of science, although specific activities at Material Sciences sphere is also accomplished as attested by the collaboration with internal and external research teams and established partnerships in projects and research contracts. The broadening of analytical capabilities have been strengthened with the use of other complementary techniques, such as INAA at ITN, TXRF at INETI, and synchrotron radiation XRF at the LURE.

A significant effort for modernisation and for the broadening of analytical capabilities have been favoured at the Ion Beam Laboratory group by stimulating experimental development projects. Thus, the PIGE (Particle Induced X-ray Emission) set-up and the Microprobe facility are being developed at the Van de Graaff accelerator. Important contributions from both techniques, are expected to the Biomedical and Environmental current research activities and open interesting possibilities in other fields as Material and Geological Sciences.

The attention that is being dedicated to Biomedical Sciences, is centred both in Environmental Health/Occupational applications and in environmental toxicity studies. On the other hand the assiduous collaboration with medical teams favoured the settlement of PIXE as a recognised analytical technique for elemental determinations in clinical diagnosis and toxicity studies.

Research Team

Researchers –	4*	(3 PhD)
Research Students –	1	(PhD Students)
Undergraduate Students –	5	
Technicians –	1	

* 1 from FCUL and 1 from FCT/UNL

Publications

Journals –	9	and 7 in press
Proceedings –	1	
Conf. Commun.:	2	
Theses:		
Lic. –	2	

	10 ³ PTE
Expenditure:	1 629
Missions:	662
Other Expenses:	944
Hardware & Software:	23
Other Equipment:	0

		10 ³ PTE
Funding:		2 421
External Projects:	1997	168 ⁽¹⁾
	1998	2 253
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⁽¹⁾ Funding not used in 1997		

Health Related Applications

Modifications in *Crassostrea gigas* shell Composition Exposed to High Concentrations of Lead

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Abstract

Oysters *Crassostrea gigas* were exposed to two different lead concentrations, 470 and 790 $\mu\text{g l}^{-1}$, with the main objective of finding any alterations on shell biochemical composition, namely amino acids and metal ions. Whole shell elemental composition showed that Pb levels are higher and Ca, Na and Co levels are lower in contaminated than in control oysters. Elemental analysis using Proton Induced X-ray Emission (PIXE) showed lower Zn levels in the foliated layer and higher Cl in the prismatic layer in contaminated rather than in the control oysters. Mantle Pb content seems to be proportional to foliated shell layer Pb content. Pb levels of the whole soft tissue showed that this trace metal is similar for both concentrations, suggesting a possible regulatory mechanism that sends to excess Pb to the shell through the mantle. Shell amino acid composition is altered in treated oysters, mainly in the ones submitted to 470 $\mu\text{g l}^{-1}$, having higher asparagine, glycine and cystine and lower threonine, proline, valine, isoleucine, leucine, phenylalanine and arginine. Pb seems to affect shell amino acid secretion.

Aquatic Toxicology **40** (1998) 323-334.

Pollution Assessment in the Trancão River Basin (Portugal) by PIXE, EDXRF and Isotopic Analysis

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(see *Environmental Analytical Chemistry*)

Biological Monitoring of Toxic Metals - Steel Workers Respiratory Health Survey

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Abstract

The aim of this work is to search for respiratory system aggressors to which workers are submitted in their labouring activity. Workers from one sector of a steel plant in Portugal, *Siderurgia Nacional* (SN), were selected according to the number of years of exposure and labouring characteristics. The work reports on blood elemental contents alterations and lung function tests to determine an eventual bronchial hyper-reactivity. Aerosol samples collected permit an estimate of indoor air quality and airborne particulate matter characterisation to further check whether the elemental associations and alterations found in blood may derive from exposure.

Blood and aerosol elemental composition was determined by PIXE and INAA. Respiratory affections were verified for 24% of the workers monitored. There are indications that the occurrence of affections can be associated with the total working years. The influence of long-term exposure, health status parameters, and lifestyle factors in blood elemental variations found was investigated.

Nucl. Instr. and Meth. B, in press.

Airborne Particulate Matter Localisation in the Human Respiratory System

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Abstract

Respired particles accumulated in the epithelial regions of trachea and bronchi were identified and characterised using microPIXE elemental mapping of thin frozen sections carried out at the Oxford Nuclear Microprobe facility.

Isolated particles with diameters of 2 to 10 μm could be detected, mainly at the trachea epithelial surface. In bronchi respiratory mucosa, granular regions can also be observed that may correspond to particle agglomerations (2 to 4 μm diameters) and/or inclusions in macrophages. Particles, observed in the upper regions of the respiratory tract consist mainly of earth crust elements such as Al, Si, Ca and Fe. Occasionally, Ti and Zn are also present. Particles observed in the bronchi have a more varied chemical composition. Elements such as V, Cr, Mn, Fe, Cu, Zn were detected, mainly in association with S, K, Ca or Si.

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Microprobe Analysis of Teeth by Synchrotron Radiation: Environmental Contamination

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Abstract

Microbeam synchrotron radiation was used to analyze nine teeth, collected *post-mortem*, five from a miner and four from a fisherman, in order to evaluate the influence of living habits in dental elemental composition. All teeth from the fisherman were healthy, and those from the miner some were carious, and a few of them were filled with metallic amalgam. From the 5 sampled, 2 were healthy, 2 carious non-treated and 1 carious restored with amalgam.

Teeth were sliced under the vertical plane and each slice was scanned from the inner region to the surface enamel in order to determine the elemental profiles. The synchrotron microprobe was 100 μm in diameter and 18 keV in energy.

The results showed that the elemental profiles are very similar in teeth belonging to the same individual. On the other hand, the elemental contents are very different in both groups, which may be correlated with dietary habits and environmental contamination. These differences are significant in what concerns specially Mn, Sr, Br and Pb.

Concerning Br this element is present only in the teeth of the fisherman. Pb is present in higher concentrations in the miner teeth and specially deposited in dentine root and pulp regions.

No mercury was found in all the sampled non-treated teeth.

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Localização de Aerossóis Atmosféricos nas Vias Respiratórias Humanas

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Abstract

A associação da hiper-reatividade das vias respiratórias com a exposição a particulado atmosférico tem vindo a ganhar importância para a avaliação de riscos em estudos de saúde ambiental e ocupacional. Para estimar a resposta das vias respiratórias é no entanto necessário ter em conta além da caracterização das partículas atmosféricas, o grau de exposição, os efeitos fisiológicos nos tecidos expostos e onde a partícula atmosférica interage com o ambiente celular.

Pretende-se neste trabalho localizar as partículas atmosféricas, a diferentes níveis das vias respiratórias (traqueia e brônquio de indivíduos com função respiratória normal que viveram num ambiente urbano), assim como caracterizá-las quimicamente. Para a identificação e caracterização das partículas depositadas na traqueia e brônquio, secções finas das vias respiratórias foram analisadas pela técnica de Microsonda Nuclear (Oxford Nuclear Microprobe Facility).

Foram identificadas partículas com diâmetros de 2 a 10 μm na mucosa traqueal. Na mucosa e parede brônquica, regiões granulares poderão corresponder a aglomerados de partículas que atingem 2-4 μm . Estes aglomerados são também encontrados como inclusões em macrófagos, que podem ser identificados quer na periferia epitelial ou em regiões que correspondem ao tecido muscular da parede brônquica. As partículas encontradas a níveis superiores das vias respiratórias estudadas caracterizam-se essencialmente por elementos que são específicos da crosta terrestre, como o Al, Si, Ca e Fe, embora, ocasionalmente, Ti, Zn e Ba se possam também associar. As partículas encontradas a níveis inferiores (brônquio) apresentam uma maior variedade no que respeita à composição elementar. Elementos como o V, Cr, Mn, Fe, Cu, Zn foram detectados, sobretudo associados a S, K, Ca ou Si. Por outro lado, a associação de Al, Si, Ti e Ba parece estar restringida a inclusões macrofágicas (ver Fig.1).

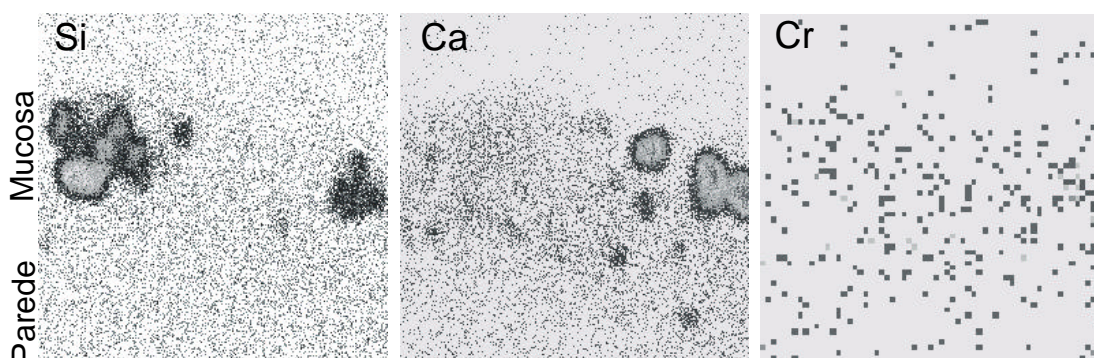


Fig. 1 – Mapas de distribuição de Si, Ca e Cr, resultantes de um varrimento ($50 \times 50 \mu\text{m}$) da parede traqueal, evidenciam diferentes composições de aerossóis depositados.

Estudo da Contaminação por Metais Pesados na Bacia Hidrográfica do Rio Trancão

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(see *Environmental Analytical Chemistry*)

Current Work

Biological Monitoring of Mercury and other Toxic Elements in Steel Workers

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Abstract

The work is related to the IAEA project POR-9479. Workers exposed to metals from one sector of a steel plant in Portugal, *Siderurgia Nacional* (SN), selected according to the number of years of exposure and labouring characteristics have been monitored for elemental concentrations in blood and respiratory function. Aerosols at the work place are also being controlled. A PM10 air sampler was used for fractionation of aerosols in two size fractions, i.e., a fine fraction (particles with aerodynamic diameter smaller than 2µm) and a coarse fraction (particles with aerodynamic diameter comprehended between 2µm and 10 µm).

An animal model was also used in order to evaluate physiological respiratory system alterations directly correlated to the inhaled aerosols at the work place.

More than 20% of the subjects monitored have respiratory affections. Also, the occurrence of complains is consistently associated with the total number of working years. To evaluate possible links between air pollutants and respiratory symptoms the blood contents were determined for Hg, and other elements with environmental relevance such as, As, Cd, and Pb, and for essential elements as for instance, Cu, Zn, and Se.

Elemental analysis was carried out by both INAA and PIXE techniques. A multivariate approach of data permit to establish influence factors, such as exposure, age and living habits, for the elemental variations observed.

Part of this work has also been submitted to the 5th International Conference on Mercury as a Global Pollutant", Rio de Janeiro, Brazil, May 1999

